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(71) Applicants:
• **China Petroleum & Chemical Corporation**
Beijing 100029 (CN)
• **RESEARCH INSTITUTE OF PETROLEUM PROCESSING,**
SINOPEC
Beijing 100083 (CN)

(72) Inventors:
• **WU, Zhiguo**
Beijing 100083 (CN)

- **XIE, Wenhua**
Beijing 100083 (CN)
- **XIE, Chaogang**
Beijing 100083 (CN)
- **LIU, Qiang**
Beijing 100083 (CN)
- **MU, Xuhong**
Beijing 100083 (CN)
- **ZHANG, Jiushun**
Beijing 100083 (CN)
- **LUO, Yibin**
Beijing 100083 (CN)
- **SHU, Xingtian**
Beijing 100083 (CN)
- **YAN, Chenghan**
Beijing 100083 (CN)

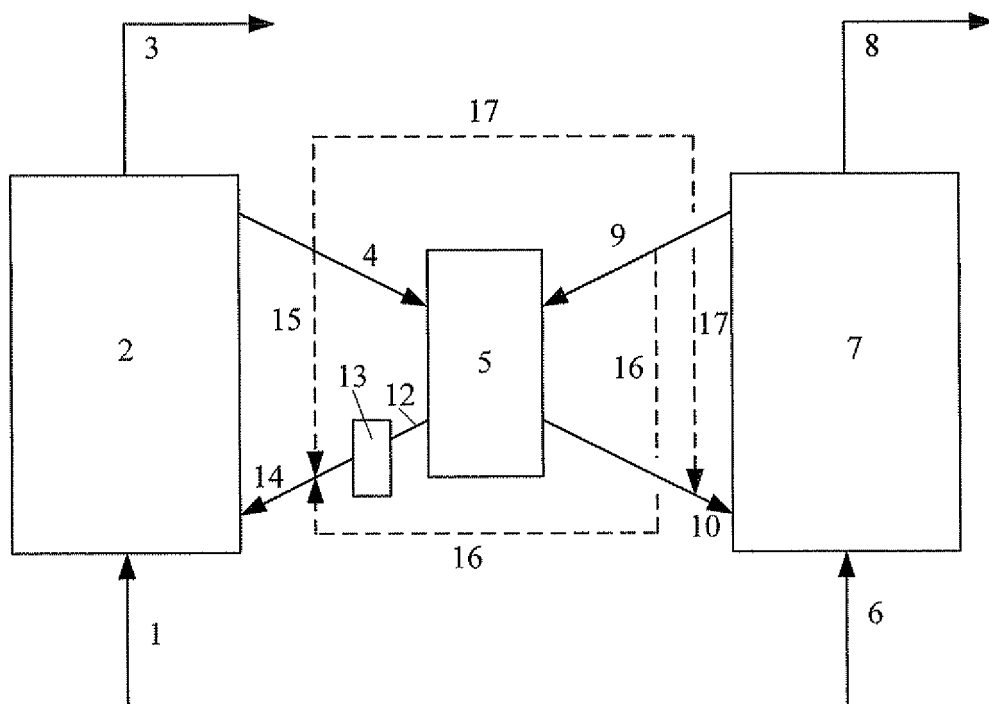
(74) Representative: **Schwabe - Sandmair - Marx**
Patentanwälte
Stuntzstrasse 16
81677 München (DE)

(54) **A PROCESS FOR PRODUCING ETHYLENE FROM ETHANOL COMBINING THE CATALYTIC CONVERSION OF HYDROCARBONS**

(57) A process for producing ethylene from ethanol combining the catalytic conversion of hydrocarbons: an ethanol feedstock is contacted with a Y-zeolite containing catalyst to give a product stream, and a coked catalyst and an target product of ethylene are obtained after separating the reaction stream; a hydrocarbon feedstock is contacted with a Y-zeolite containing catalyst to give a product stream, a spent catalyst and an oil vapor are obtained after separating the reaction stream, and the oil vapor is further separated to give the products such as gas, gasoline and the like; a part or all of the coked catalyst and a part or all of the spent catalyst enter the regenerator for the coke-burning regeneration, and the regenerated catalyst is divided into two portions, wherein

one portion returns to be contacted with the hydrocarbon feedstock, and the other portion, after cooling, returns to be contacted with ethanol feedstock. This process not only reasonably utilizes the excessive thermal energy of the hydrocarbon conversion, but also solves the problem of heat supply for the conversion of ethanol, thus ensuring the continuous catalytic conversion of ethanol and generating enormous economic benefits. For the catalytic conversion of the ethanol, the content of ethylene is 95 vol% or more in the gas product; and the conversion of ethylene is not less than 99%. For the catalytic conversion of the hydrocarbons, the yield for the light olefins increases slightly by at least 2 mol%.

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Description

FIELD OF THE INVENTION

5 **[0001]** The present invention relates to a process for producing ethylene from ethanol, more particular, to a process for producing ethylene from ethanol combining the catalytic conversion of hydrocarbons.

BACKGROUND OF THE INVENTION

10 **[0002]** The global petroleum supply-demand contradiction is increasingly prominent at the beginning of the 21st century. Along with the increased demand for various petroleum and petrochemical products, the price of crude oil in the market is continuously increased. This situation leads to persisting high market-prices of important chemical products such as light olefins (especially ethylene and propylene) and light ethers (such as dimethyl ether, ethyl ether, etc), using petroleum and petrochemical products as feedstock. Therefore, it is one choice of solving these problems to seek for another
15 substituting feedstock such as by-product ethanol from agriculture and forestry, and methanol prepared from natural gas or coal to produce light olefins and light ethers.

[0003] The process for preparing ethylene from ethanol is to carry out the dehydration reaction $\text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_2=\text{CH}_2 + \text{H}_2\text{O}$ at 140-400°C with a suitable catalyst. At the beginning of 1980's, India and Brazil built up industry-scale devices for converting ethanol to ethylene, using $\text{SiO}_2\text{-Al}_2\text{O}_3$ as catalyst and adopting fixed bed and fluidized bed reactors
20 altogether. For the balance of heat, an additional fuel will be added when the catalyst is regenerated.

[0004] The process disclosed in US 6,441,261 is to convert oxygenates (methanol, etc) to light olefins, e.g. ethylene and propylene, on a silicoaluminophosphate molecular sieve catalyst under a relative high pressure.

[0005] US 6,343,839 and US 5,914,433 convert oxygenates (methanol, etc) to light olefins and fractionate out the propylene and/or butene therein for cracking, thereby enhancing the yield of ethylene and propylene. Although the above
25 processes also use fluidized bed operation, it is seen from the data of the examples that the yield of coke is only 2%. With a low yield of coke, the heat of the system is difficult to be balanced, and an external heat supply is generally needed.

[0006] US 6,049,017 increases the yield of light olefins by separating the product containing C_4 components and converting them to ethylene and propylene on a non-molecular sieve catalyst. This process may be used in the catalytic cracking or the methanol dehydration for producing ethylene and propylene.

30 **[0007]** US 4,148,835 uses a shape-selective molecular sieve catalyst and derivatives thereof to convert alcohols (especially methanol) to a product mainly containing light olefins, but this patent does not mention of the process.

[0008] The ethanol dehydration reaction is an endothermic reaction, and is conducted at a certain temperature. Although coke deposition may occur during the reaction, the amount of the coke is insufficient to balance the heat of the process. In summary, all the prior arts provide the heat in a manner of supplying an external fuel, making the process
35 too complicated or the energy consumption too high.

SUMMARY OF THE INVENTION

40 **[0009]** Based on the prior art, the object of the present invention is to provide a process for producing ethylene from ethanol combining the catalytic conversion of hydrocarbons.

[0010] According to the present invention, the process for producing ethylene from ethanol combining the catalytic conversion of hydrocarbons comprises the following steps:

- 45 (1) An ethanol feedstock is contacted with a Y-zeolite containing catalyst to give a product stream, and a coked catalyst and a target product of ethylene are obtained after separating the reaction stream;
- (2) A hydrocarbon feedstock is contacted with a Y-zeolite containing catalyst to give a product stream, a spent catalyst and an oil vapor are obtained after separating the reaction stream, and the oil vapor is further separated to give the products such as gas, gasoline and the like;
- 50 (3) A part or all of the coked catalyst in step (1) and a part or all of the spent catalyst in step (2) enter a regenerator for the coke-burning regeneration, and the regenerated catalyst is divided into two portions, wherein one portion returns to step (2), and the other portion returns to step (1) after cooling.

[0011] The ethanol content in the ethanol feedstock in the present invention is 50-100 wt%, preferably 70-100 wt%, and more preferably 90-100 wt%. A small amount of impurities such as water and methanol may be contained in the ethanol feedstock.

55 **[0012]** Said hydrocarbon feedstock is selected from the group consisting of C_4^+ hydrocarbons, crude oil, gasoline, diesel oil, vacuum gas oil, coker gas oil, deasphalted oil, hydrogenated bottom, atmospheric residuum, vacuum residuum and mixtures thereof; and it is preferably selected from the group consisting of vacuum gas oil, coker gas oil, deasphalted

oil, hydrogenated bottom, atmospheric residuum, vacuum residuum and mixtures thereof.

[0013] Said Y-zeolite containing catalyst may contain a Y-zeolite and an optional other molecular sieve, but not contain inorganic oxides and clay, wherein the weight ratio of the other molecular sieve to the Y-zeolite is 0-10. Said Y-zeolite containing catalyst preferably contains inorganic oxides and/or clay, a Y-zeolite, and an optional other molecular sieve, wherein the weight ratio of the other molecular sieve to the Y-zeolite is 0-10, and the total weight of the other molecular sieve and the Y-zeolite comprises 10-60% of the catalyst.

[0014] Said Y-zeolite includes Y-type zeolite and their derivative or modified zeolites, and is selected from the group consisting of Y, HY, REY, REHY, USY, REUSY and mixtures thereof.

[0015] Said other molecular sieve is one or more selected from meso porous zeolites, Beta-zeolites, and SAPO-molecular sieves.

[0016] Said meso porous zeolite includes ZRP series (rare earth-modified), ZSP series (iron-modified), ZSM series zeolites and their derivative or modified zeolites. For the more detailed description of ZRP, a reference may be made to US 5,232,675. Said ZSM series zeolite is selected from the group consisting of ZSM-5, ZSM-11, ZSM-12, ZSM-22, ZSM-23, ZSM-35, ZSM38, ZSM-48, and other zeolites having a similar structure. For more detailed description of ZSM-5, a reference may be made to US 3,702,886.

[0017] A more preferred Y-zeolite containing catalyst contains Y-zeolites, meso porous zeolites, inorganic oxides, and clay, wherein the weight ratio of the meso porous zeolite to the Y-zeolite is 0.1-10, and the total weight of the meso porous zeolite and the Y-zeolite accounts for 10-60% of total weight of the catalyst.

[0018] Said inorganic oxide is selected from the group consisting of alumina, silica, amorphous silica-alumina and mixtures thereof. The clay is kaolin and/or halloysite.

[0019] The reaction conditions in step (1) are a temperature of 200-450°C, preferably 250-400°C, a pressure (gauge) of 0-0.8 MPa, a weight ratio of the catalyst to the ethanol feedstock of 0.05-20, and a weight hourly space velocity of 0.05-10 h⁻¹, preferably 0.1-5 h⁻¹.

[0020] The reaction conditions in step (2) are a temperature of 400-700°C, preferably 450-600°C, a pressure (gauge) of 0-0.8 MPa, a weight ratio of the catalyst to the hydrocarbon feedstock of 1-30, and a contact time of 1-10 seconds.

[0021] The catalytic conversion process in step (2) comprises conventional catalytic cracking processes and various family processes such as the DCC process, CPP process, MIP process, MIP-CGP process, MGD process, MGG process, ARGG process, SHMP process and the like.

[0022] The proportion of the coked catalyst in step (1) subjected to coke-burning is 0.5-100%, preferably 5-60%, more preferably 8-40% by the total weight of the coked catalyst. When a portion of the coked catalyst in step (1) enters the regenerator for the coke-burning regeneration, the remaining coked catalyst returns to step (1) and/or step (2), and said portion of the coked catalyst subjected to coke-burning comprises 0.5-99%, preferably 5-60%, more preferably 8-40% by the total weight of the coked catalyst.

[0023] The proportion of the spent catalyst in step (2) subjected to coke-burning is 1-100%, preferably 50-100%, more preferably 80-100% by the total weight of the spent catalyst. When a portion of the spent catalyst in step (2) enters the regenerator for the coke-burning regeneration, the remaining spent catalyst returns to step (1), and said portion of the spent catalyst comprises 1-99%, preferably 50-99%, more preferably 80-99% by the total weight of the spent catalyst.

[0024] The regeneration in step (3) is one-stage regeneration or two-stage regeneration, and said regenerated catalyst is a partially regenerated catalyst (i.e. semi-regenerated catalyst) and/or a full regenerated catalyst. The weight ratio of the coked catalyst and the spent catalyst entering the regenerator for the coke-burning regeneration is no more than 1.0, preferably no more than 0.5, more preferably no more than 0.2.

[0025] The reactors used in step (1) and step (2) are both catalyst-movable reactors, and are selected from the group consisting of a fluidized bed, a riser, a descending transfer line reactor, a moving bed, a composite reactor of riser and fluidized bed, a composite reactor of riser and descending transfer line, a composite reactor of two or more risers, a composite reactor of two or more fluidized beds, a composite reactor of two or more descending transfer lines, and a composite reactor of two or more moving beds. Each of the above reactors may be divided into two or more reaction zones. The preferred reactor in step (1) is a fluidized bed, more preferably a dense-phase fluidized bed. The preferred reactor in step (2) is a riser. Said riser is one or more selected from an iso-diameter riser, an equal-velocity riser, and various variable-diameter risers. Said fluidized bed is one or more selected from a fixed fluidized bed, a particulate fluidization bed, a bubbling bed, a turbulent bed, a quick bed, a transfer bed, and a dense-phase fluidized bed.

[0026] An existing catalytic cracking reactor may be used as the aforesaid reactor. Alternatively, a necessary modification may be made to an existing catalytic cracking reactor. Also the reactors having a similar structure and function to an existing catalytic cracking reactor can be used.

[0027] The product separation device may be the same one shared in Step (1) and Step (2), or the product separation device used in Step (1) is different from that in Step (2). The excessive ethanol separated in step (1) may return to step (1). The C₄⁺ light hydrocarbons separated in step (2) may return to step (1) and/or step (2).

[0028] The regenerated catalyst returning to the reactor of step (1) is first cooled down to 200-450°C in a direct heat exchange mode or an indirect heat exchange mode. The direct heat exchange mode is to carry out heat exchange by

directly contacting the regenerated catalyst with the air having a relatively low temperature. The air is a part or all of the air compressed by an air compressor and delivered to the regenerator, that is, the high temperature thermal energy from a portion of regenerated catalyst is used to preheat the air entering the regenerator. The direct heat exchanger is in a type of fluidized bed or riser, and the cooled catalyst separated by a cyclone separator enters the catalytic conversion reactor of ethanol after stripping off the gas impurities (nitrogen, oxygen, carbon dioxide and the like) with the hot steam. The indirect heat exchange mode is to use an indirect heat exchanger, wherein the hot catalyst passes through the tube side and the steam passes through the shell side.

[0029] The process for producing ethylene from ethanol combining the catalytic conversion of hydrocarbons according to the present invention, not only reasonably utilizes the excessive thermal energy of the hydrocarbon conversion, but also solves the problem of heat supply for the conversion of ethanol, thus ensuring the continuous catalytic conversion of ethanol and generating enormous economic benefits. For the catalytic conversion of the ethanol, the content of ethylene is 95 vol% or more in the gas product; and the conversion of ethylene is not less than 99%. For the catalytic conversion of the hydrocarbons, the yield for the light olefins increases slightly by at least 2 mol%.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

Fig. 1 is a schematic flowsheet of the process for producing ethylene from ethanol combining the catalytic conversion of hydrocarbons according to an embodiment of the present invention.

PREFERRED EMBODIMENTS OF THE INVENTION

[0031] The process of the present invention will be further illustrated in reference to the drawing, but the present invention is not limit thereto.

[0032] Fig. 1 is a schematic flowsheet of the process for producing ethylene from ethanol combining the catalytic conversion of hydrocarbons according to an embodiment of the present invention.

[0033] An ethanol feedstock from line 1 is introduced into the reactor 2 and contacted with a Y-zeolite containing regenerated catalyst from line 14 to react at 200-450°C, under a pressure (gauge) of 0-0.8MPa, at a weight ratio of the catalyst to ethanol feedstock of 0.05-20, with a weight hourly space velocity of 0.1-10 h⁻¹. A coked catalyst and a product stream are obtained after separating the reaction stream. The product stream is withdrawn through the line 3 and further separated to give the target product of ethylene. The coked catalyst may be partially or completely introduced into the regenerator 5 through the line 4 for the coke-burning regeneration, and a portion of the coked catalyst may return to the reactor 2 sequentially through the lines 15 and 14 or return to the reactor 7 sequentially through the lines 17 and 10.

[0034] The hydrocarbon feedstock from line 6 is introduced into the reactor 7 and contacted with a Y-zeolite containing regenerated catalyst from the line 10 to react at 400-700°C, under a pressure (gauge) of 0-0.8MPa, at a weight ratio of the catalyst to the hydrocarbon feedstock of 1-30, with a contact time of 1-10 s. A spent catalyst and an oil vapor are obtained after separating the reaction stream, wherein the oil vapor is withdrawn through the line 8 and further separated to give the products such as gas, gasoline, diesel oil and the like (not shown in the figure). After stripping, the spent catalyst is completely or partially introduced into the regenerator 5 through the line 9 for the coke-burning regeneration, and a portion of the spent catalyst may return to the reactor 2 sequentially through the lines 16 and 14.

[0035] The weight ratio of the coked catalyst and the spent catalyst entering the regenerator 5 for the coke-burning regeneration is no more than 1.0, preferably no more than 0.5, more preferably no more than 0.2. The regenerated catalyst, which is coke-burning regenerated in the regenerator 5, is divided into two portions, wherein one portion returns to the reactor 7 through line 10, and the other portion sequentially enters the heat exchanger 13 through the line 12, cools therein, and then returns to the reactor 2 through the line 14.

[0036] The process of the present invention will further be illustrated by the following examples, but the present invention is not limit thereto.

Example 1

[0037] The ethanol feedstock and hydrocarbon feedstock used in this example were an ethanol feedstock containing 95% ethanol brewed from grains and vacuum gas oil (VGO), respectively, and the properties of VGO are shown in Table 1. The catalyst used in this example was CGP-1 (containing 25 wt% of REY-zeolite, 10 wt% of ZSP-zeolite, and the balanced support, all based on the total weight of the catalyst) produced by SINOPEC Catalyst Company Qilu Division.

[0038] The ethanol feedstock was introduced into a fluidized bed reactor and contacted with the CGP-1 catalyst to react at 340°C, under a pressure (gauge) of 4.1 MPa, at a weight ratio of the catalyst to the ethanol feedstock (catalyst/alcohol ratio) of 1, with a weight hourly space velocity of 1.0 h⁻¹. A coked catalyst and a product stream were obtained

after separating the product stream. The product stream was further separated to give the target product of ethylene. The product distribution is shown in Table 2. The coked catalyst was divided into two portions, wherein 20 wt% of the coked catalyst was introduced into the regenerator for the coke-burning regeneration, and the remaining 80 wt% of the coked catalyst returned to the fluidized bed reactor through the inner recycle.

[0039] The preheated VGO was injected into a riser reactor after the steam atomization at a weight ratio of the steam to VGO was 0.1:1. VGO was contacted with the hot CGP-1 catalyst in the riser to react at 500°C, under a pressure (gauge) of 0.1 MPa, at a weight ratio of the catalyst to VGO (catalyst/oil ratio) of 6, with a reaction time of 3 seconds. The mixture of the oil vapor and the catalyst rose along the riser to the outlet of the riser. The reaction product and the spent catalyst were separated. The reaction product was introduced into the settler and then into the subsequent separation system to further separate into various products. The product distribution is shown in Table 2. The spent catalyst entered the stripper under the action of gravity to strip with the steam, and it was then introduced into the regenerator for the coke-burning regeneration.

[0040] 20 wt% of the coked catalyst and all the spent catalyst were regenerated in the regenerator, wherein the weight ratio of the coked catalyst and the spent catalyst entering the regenerator for the coke-burning regeneration is about 0.02. After the regeneration, the regenerated catalyst were divided into two portions, wherein 85 wt% of the regenerated catalyst, having a temperature of 660°C, returned to the riser for the recycling use, and the remaining 15 wt% of the regenerated catalyst was cooled down to 410°C and returned to the fluidized bed for the recycling use.

[0041] The testing results demonstrated that by combining the catalytic conversion of ethanol and the catalytic conversion of hydrocarbons, the heat between the two conversions can be balanced, and there is no need for the external fuel or other heat sources. For the catalytic conversion of the ethanol, the content of ethylene is as high as 95.79 vol% in the gas product; and the conversion of ethylene is as high as 99%. Further, the inventors also found that:

(1) The catalytic conversion of ethanol had not any effect on the crystalline phase of the catalyst CGP-1; and in comparison of the catalyst's acidity prior to the catalytic conversion, the catalyst's acidity decreased slightly after the catalytic conversion; and

(2) For the catalytic conversion of the hydrocarbons, the yield for the light products increases slightly by 2 mol% by combining the catalytic conversion of ethanol and the catalytic conversion of the hydrocarbons, the reason for which is believed that the catalyst's acidity is decreased.

Example 2

[0042] In this example, the ethanol feedstock is identical to that of Example 1; and the hydrocarbon feedstock is an atmospheric residuum. The properties of the atmospheric residuum are shown in Table 1. The catalyst used in this example was MMC-2 (containing 10 wt% of USY-zeolite, 20 wt% of ZSM-5 zeolite, and the balanced support, all based on the total weight of the catalyst) produced by SINOPEC Catalyst Company Qilu Division.

[0043] The ethanol feedstock was introduced into a fluidized bed reactor and contacted with the MMC-2 catalyst to react at 360°C, under a pressure (gauge) of 0.1 MPa, at a weight ratio of the catalyst to the ethanol feedstock (catalyst/alcohol ratio) of 5, with a weight hourly space velocity of 1.5 h⁻¹. A coked catalyst and a product stream were obtained after separating the reaction stream. The product stream was further separated to give the target product of ethylene. The product distribution is shown in Table 2. The coked catalyst was divided into two portions, wherein 30 wt% of the coked catalyst was introduced into the regenerator for the coke-burning regeneration, and the remaining 70 wt% of the coked catalyst returned to the fluidized bed reactor through the inner recycle.

[0044] The preheated atmospheric residuum was injected into a riser reactor after the steam atomization at a weight ratio of the steam to the atmospheric residuum was 0.1:1. The atmospheric residuum was contacted with the hot MMC-2 catalyst in the riser to react at 550°C, under a pressure (gauge) of 0.1 MPa, at a weight ratio of the catalyst to the atmospheric residuum (catalyst/oil ratio) of 8, with a reaction time of 4 seconds. The mixture of the oil vapor and the catalyst rose along the riser to the outlet of the riser. The reaction product and the spent catalyst were separated. The reaction product was introduced into the settler and then into the subsequent separation system to further separate into various products. The product distribution is shown in Table 2. The spent catalyst entered the stripper under the action of gravity to strip with the steam, and it was then introduced into the regenerator for the coke-burning regeneration.

[0045] 30 wt% of the coked catalyst and all the spent catalyst were regenerated in the regenerator, wherein the weight ratio of the coked catalyst and the spent catalyst entering the regenerator for the coke-burning regeneration is about 0.02. After the regeneration, the regenerated catalyst were divided into two portions, wherein 80 wt% of the regenerated catalyst, having a temperature of 680°C, returned to the riser for the recycling use, and the remaining 20 wt% of the regenerated catalyst was cooled down to 410°C and returned to the fluidized bed for the recycling use.

[0046] The testing results demonstrated that by combining the catalytic conversion of ethanol and the catalytic conversion of hydrocarbons, the heat between the two conversions can be balanced, and there is no need for the external fuel or other heat sources. For the catalytic conversion of the ethanol, the content of ethylene is as high as 98.3 vol%

in the gas product; and the conversion of ethylene is as high as 99.1 %. Further, the inventors also found that:

(1) The catalytic conversion of ethanol had not any effect on the crystalline phase of the catalyst MMC-2; and in comparison of the catalyst's acidity prior to the catalytic conversion, the catalyst's acidity decreased slightly after the catalytic conversion; and

(2) For the catalytic conversion of the hydrocarbons, the yield for the light products increases slightly by 2 mol% by combining the catalytic conversion of ethanol and the catalytic conversion of the hydrocarbons, the reason for which is believed that the catalyst's acidity is decreased.

Table 1

Feedstock Properties	VGO	Atmospheric residuum
Density (20°C), g/cm ³	0.9526	0.9387
Sulfur content, ppm	11000	12000
Nitrogen content, ppm	916	647
Carbon residue, m%	12.4	9.2
C, m%	86.3	85.95
H, m%	11.52	11.83
Kinetic viscosity, mm ² /s		
80°C	1102.3	325.1
100°C	650.7	129.5
Freezing point, °C	45	35
True boiling point, °C	>450	>350
Vanadium, ppm	2.1	1.7
Nickel, ppm	42	30

Table 2

Example	1	2
Catalyst type	CGP-1	MMC-2
Catalytic conversion of ethanol		
Reaction conditions		
Temperature, °C	340	360
Pressure (gauge), MPa	0.1	0.1
Catalyst/alcohol ratio	1	5
WHSV, h ⁻¹	1.0	1.5
Product distribution, vol%		
Ethylene	95.79	98.32
Propylene	1.18	0.29
Iso-butane	0.72	0.15
Total pentane	0.45	0
Total pentene	0.25	0.31
C ₆ ⁺ hydrocarbons	0.54	0.53
Conversion of ethanol, %	99.1	99.5

(continued)

Example	1	2
Selectivity to ethylene, %	98	98.3
Carbon base ethylene yield*, m%	89.52	99.78
Catalytic conversion of hydrocarbons		
Reaction conditions		
Temperature, °C	500	550
Pressure (gauge), MPa	0.1	0.1
Catalyst/oil ratio	6	6
Time on stream, s	3	3
Product distribution, wt%		
Dry gas	10.56	3.17
LPG	44.78	18.04
Gasoline	21.32	48.26
Diesel oil	6.89	18.73
Heavy oil	3.18	4.56
Coke	13.28	7.24
* Carbon base ethylene yield = Carbon content in the target product/ carbon content in the ethanol feedstock		

Claims

1. A process for producing ethylene from ethanol combining the catalytic conversion of hydrocarbons, **characterized in that** said process comprises the following steps:

(1) An ethanol feedstock is contacted with a Y-zeolite containing catalyst to give a product stream, and a coked catalyst and a target product of ethylene are obtained after separating the reaction stream;
 (2) A hydrocarbon feedstock is contacted with a Y-zeolite containing catalyst to give a product stream, a spent catalyst and an oil vapor are obtained after separating the reaction stream, and the oil vapor is further separated;
 (3) A part or all of the coked catalyst in step (1) and a part or all of the spent catalyst in step (2) enter a regenerator for the cake-burning regeneration, and the regenerated catalyst is divided into two portions, wherein one portion returns to step (2) and the other portion returns to step (1) after cooling.

2. The process according to claim 1, **characterized in that** the content of the ethanol in said ethanol feedstock is 50-100% by weight.
3. The process according to claim 1, **characterized in that** the content of the ethanol in said ethanol feedstock is 70-100% by weight.
4. The process according to claim 1, **characterized in that** the content of the ethanol in said ethanol feedstock is 90-100% by weight.
5. The process according to claim 1, **characterized in that** said hydrocarbon feedstock is selected from the group consisting of C4+ hydrocarbons, crude oil, gasoline, diesel oil, vacuum gas oil, coker gas oil, deasphalted oil, hydrogenated bottom, atmospheric residuum, vacuum residuum and mixtures thereof.
6. The process according to claim 1, **characterized in that** said hydrocarbon feedstock is selected from the group consisting of vacuum gas oil, coker gas oil, deasphalted oil, hydrogenated bottom, atmospheric residuum, vacuum residuum and mixtures thereof.

7. The process according to claim 1, **characterized in that** said Y-zeolite containing catalyst comprises a Y-zeolite and an optional other molecular sieve, but not contain inorganic oxides and clay.
- 5 8. The process according to claim 1, **characterized in that** said Y-zeolite containing catalyst comprises a Y-zeolite, an optional other molecular sieve, and inorganic oxides and/or clay.
9. The process according to claim 7 or 8, **characterized in that** said other molecular sieve is one or more selected from meso porous zeolites, Beta-zeolites, and SAPO-molecular sieves.
- 10 10. The process according to claim 7 or 8, **characterized in that** the weight ratio of said other molecular sieve to the Y-zeolite is 0-10.
11. The process according to claim 1, **characterized in that** said Y-zeolite containing catalyst contains Y-zeolites, meso porous zeolites, inorganic oxides, and clay.
- 15 12. The process according to claim 11, **characterized in that** the weight ratio of said meso porous zeolite to the Y-zeolite is 0.1-10, and the total weight of the meso porous zeolite and the Y-zeolite accounts for 10-50% of total weight of the catalyst.
- 20 13. The process according to claim 1, 7 or 8, **characterized in that** said Y-zeolite is selected from the group consisting of Y, HY, REY, REHY, USY, REUSY and mixtures thereof.
- 25 14. The process according to claim 9 or 11, **characterized in that** said meso porous zeolite includes ZRP series, ZSP series, and ZSM series zeolites, as well as their derivative or modified zeolites.
- 30 15. The process according to claim 7 or 8, **characterized in that** said inorganic oxide is selected from the group consisting of alumina, silica, amorphous silica-alumina, and mixtures thereof, and the clay is kaolin clay and/or halloysite.
- 35 16. The process according to claim 1, **characterized in that** the reaction conditions in step (1) are a temperature of 200-450°C, a gauge pressure of 0-0.8 MPa, a weight ratio of the catalyst to the ethanol feedstock of 0.05-20, and a weight hourly space velocity of 0.05-10 h⁻¹.
- 40 17. The process according to claim 16, **characterized in that** the reaction conditions in step (1) are a temperature of 250-400°C, and a weight hourly space velocity of 0.1-5 h⁻¹.
- 45 18. The process according to claim 1, **characterized in that** the reaction conditions in step (2) are a temperature of 400-700°C, a gauge pressure of 0-0.8 MPa, a weight ratio of the catalyst to the hydrocarbon feedstock of 1-30, and a contact time of 1-10 seconds.
- 50 19. The process according to claim 18, **characterized in that** the reaction conditions in step (2) are a temperature of 450-600°C.
- 55 20. The process according to claim 1, **characterized in that** the proportion of the coked catalyst in step (1) subjected to eolce-burning is 0.5-100% by the total weight of the coked catalyst.
21. The process according to claim 1 or 20, **characterized in that** when a portion of the coked catalyst in step (1) enters the regenerator for the coke-burning regeneration, the remaining coked catalyst returns to step (1) and/or step (2), and said portion of the coked catalyst comprises 0.5-99% by the total weight of the coked catalyst.
22. The process according to claim 1, **characterized in that** the proportion of the spent catalyst in step (2) subjected to coke-burning is 1-100% by the total weight of the spent catalyst.
23. The process according to claim 1 or 22, **characterized in that** when a portion of the spent catalyst in step (2) enters the regenerator for the coke-burning regeneration, the remaining spent catalyst returns to step (1), and said portion of the spent catalyst comprises 1-99% by the total weight of the spent catalyst.
24. The process according to claim 1, **characterized in that** the regeneration in step (3) is one-stage regeneration or

two-stage regeneration, and said regenerated catalyst is a partially regenerated catalyst and/or a full regenerated catalyst.

25. The process according to claim 1, **characterized in that** the reactors used in step (1) and step (2) are both catalyst-movable reactors, and are selected from the group consisting of a fluidized bed, a riser, a descending transfer line reactor, a moving bed, a composite reactor of riser and fluidized bed, a composite reactor of riser and descending transfer line, a composite reactor of two or more risers, a composite reactor of two or more fluidized beds, a composite reactor of two or more descending transfer lines, and a composite reactor of two or more moving beds; and each of the above reactors can be divided into two or more reaction zones.

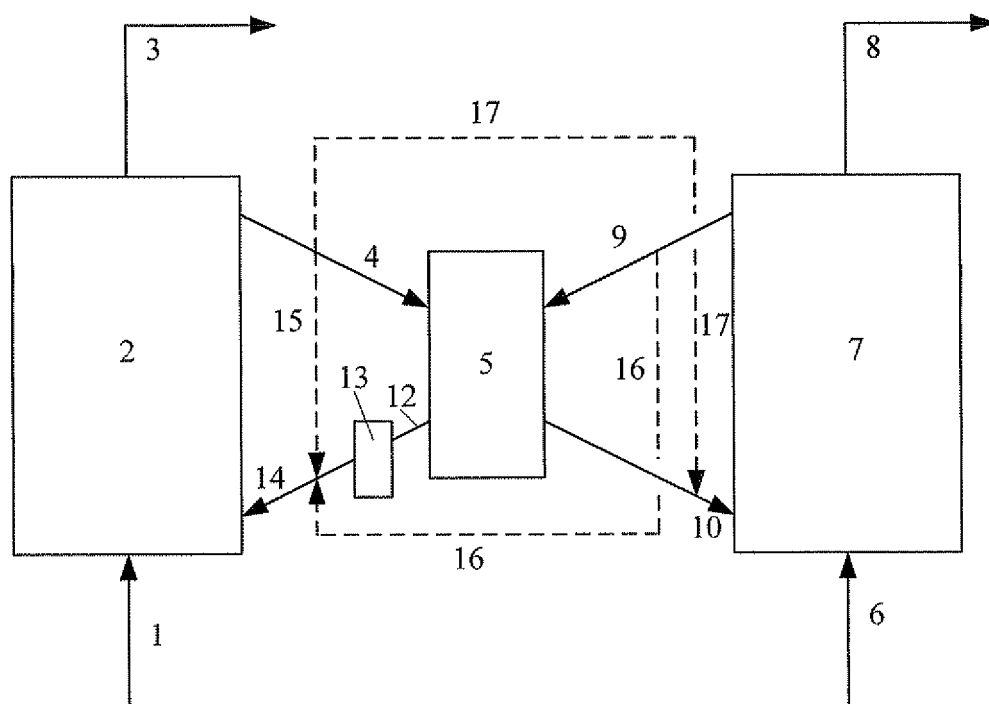
26. The process according to claim 1, **characterized in that** the reactor in step (1) is a fluidized bed, and the reactor in step (2) is a riser.

27. The process according to claim 25 or 26, **characterized in that** said riser is one or more selected from an iso-diameter riser, an equal-velocity riser, and various variable-diameter riser; and said fluidized bed is one or more selected from a fixed fluidized bed, a particulate fluidization bed, a bubbling bed, a turbulent bed, a quick bed, a transfer bed, and a dense-phase fluidized bed.

28. The process according to claim 1, **characterized in that** the regenerated catalyst returning to the reactor of step (1) is first cooled down to 200-450°C in a direct heat exchange mode or an indirect heat exchange mode.

29. The process according to claim 28, **characterized in that** said direct heat exchange mode is to carry out heat exchange by directly contacting the regenerated catalyst with the air having a relatively low temperature, and the direct heat exchanger is in a type of fluidized bed or riser; and the indirect heat exchange mode is to use an indirect heat exchanger, wherein the hot catalyst passes through the tube side and the steam passes through the shell side.

30. The process according to claim 1, **characterized in that** the weight ratio of the coked catalyst and the spent catalyst entering the regenerator for the coke-burning regeneration is no more than 1.0.



INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2007/002133

A. CLASSIFICATION OF SUBJECT MATTER		
See extra sheet		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC: C07C1/24; C07C 11/04		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
WPI; EPODOC; PAJ; CNKI; CPRS; ETHYLEN+; ETHANOL+; ETHYL W ALCOHOL; CATAL+; DEHYDRAT+; ELIMINAT+ S WATER		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4727214 A (BELGE ETAT [BE]) 23 Feb. 1988 (23.02.1988) the whole document	1-30
A	US 4698452 A (INST NATIONALE DE LA RECH SCIE [CA]) 06 Oct. 1987 (06.10.1987) the whole document	1-30
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim (S) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 06 Sep. 2007 (06.09.2007)		Date of mailing of the international search report 01 Nov. 2007 (01.11.2007)
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451		Authorized officer ZONG Qi Telephone No. (86-10)62085600

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2007/002133

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		EP 0231163 B	18.04.1990
		LU 86284 A	03.09.1987
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		AT 52074T T	15.05.1990
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US 4698452 A	06.10.1987	None	

Form PCT/ISA/210 (patent family annex) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2007/002133

CLASSIFICATION OF SUBJECT MATTER

C07C 1 / 24 (2006.01) i

C07C 11 / 04 (2006.01) n

REFERENCES CITED IN THE DESCRIPTION

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